E – 33

What Students' Thinking about Contextual Problems is

Ekasatya Aldila Afriansyah
Program Studi Pendidikan Matematika
STKIP Garut Indonesia
e_satya@yahoo.com

Abstract

There were some studies which had been investigated how students think when facing contextual problem; the case of decimal numbers problems. Some of them observed it in detail. The goal is to scaffold students' thinking and to help them be motivated in practice. The idea was an understanding of place value and relationship between numbers and decimal numbers using contextual problems. Realistic Mathematics Education underlies the design of the activities and the contexts; design research was done in two cycles. It was conducted in three phases: preliminary design, teaching experiment, and retrospective analysis. Six students and 34 students of fifth grade were involved as data; each group of students was divided into two cycles. It was held at MIN 1 Palembang, one of PMRI participant school in Palembang. Students would enable to work with contextual situations within measurement activities; number line is used as a model for supporting their understanding and reasoning. In the analysis, their reasoning was used to develop the new one of learning trajectory. The result of this study could show that the activities could bring students' understanding from the contextual situation to the formal situation. Students would not use integer number system when doing decimal number problem. Learning trajectory on this study can be used for elementary school.

Keywords: contextual problems, decimal numbers, design research Realistic Mathematics Education.

1. Introduction

The extensive studies from around the world on decimals have documented students' difficulties and weak conceptual understanding of decimals from elementary to college levels, Steinle dan Stacey [1]. Ubuz dan Yayan [2] explained about the knowledge in the domain of decimals and investigated students' performance, and also observed their difficulties in reading scales, ordering numbers, and the operation of decimals. Because of those difficulties, the teaching and learning process on decimals needs more attention.

Much of the research literature on teaching learning process about decimals separated decimals from meaningful contexts, often in order to teach students about place value, Irwin and Britt [3]. One level of knowledge involved in processing decimal numbers consists of position knowledge (involving place number names), the base ten system, and order of the places (hundredths are larger than tenth, etc.), Widjaja [4]. Practically, some students use the meaning of whole numbers and apply this knowledge on decimal number concepts when they try to solve the problem of decimals.

There are some studies investigated how students might be thought the sense of decimals which requires the application of four basic arithmetic operations. The fact that there are current studies which are provide the misconceptions of students in doing decimals without further investigation, has established a need to conduct this topic deeply. Based on what present studies have found, researcher hopes that this study can

extend previous knowledge in some way and give a contribution continuing the research about decimal number.

Although previous studies have addressed students' difficulty on decimals addition, none of them have described explicitly the way to solve it. For example, in his research, Irwin [5] stated that when you do something to one side of the point or comma, you also do it to the other side (e.g., 2,5 + 1 = 3,6). Another example, Ubuz and Yayan [2] stated that the most common errors in the addition tasks were adding the last digit of number behind the comma adding up 0,1 to the number 4,256 and 6,98, students gave the answers of 4,257 and 6,99 instead of 4,356 and 6,98. In order to overcome the difficulty, this study presents a sequence of classroom activities aimed at constructing the understanding of place value in decimal numbers.

Furthermore, according to the approach of some Indonesian textbooks, the way of teaching and learning decimals is conducted directly using algorithm. It does not present any concrete models. It is in line with the previous research from Zulkardi [6]. He stated that the topic of decimals in Indonesian textbook mainly contains sets of rules and algorithms and it lacks applications that are experientially real to the students. The meaningful situation is important in order to avoid students' misconception about decimals, Pramudiani [7]. Supporting students with a model (e.g. number line) can engage them to find some strategies which lead them to the meaningful learning situation. So, this study provides some classroom activities which are related to the experiential world of the students, it is purposed to bring students' informal knowledge or out of school reasoning experiences into school mathematics or formal knowledge.

Considering the misconception of students and also the approach of the textbook in Indonesia, this research has an aim to investigate the development of students' thinking about contextual problems in decimals through the activities. The research question is: *"How can contextual problems support students' thinking to understand decimals?"*

2. Research Method

The research method of this research that will be discussed are: (a) research approach, (b) data collection including preparation phase, pre-teaching experiment, teaching experiment, post-test, validity and reliability; and (c) data analysis including pre-test, pre-teaching experiment, teaching experiment, and post-test.

a. Research Approach

The main object of this research is to investigate students' learning of understanding the place-value of decimals. For this purpose, design research is chosen as an approach for achieving the research goals and answering the research questions. Gravemeijer & Cobb [8] stated that design research is a type of research methods aimed to develop theories about both the process of learning and the means that are designed to support that learning. Therefore, in this research, a sequence of activities is designed as means to improve educational practices in understanding of place value in decimals for grade 5 elementary school.

According to Gravemeijer & Cobb [8], there are three phases of conducting a design experiment, as follows:

a. Preliminary design

In the preliminary design, the ideas, which are implemented here, are inspired by studying literature. A sequence of instructional activities containing conjectures of students' strategies and students' thinking is developed. The conjectured hypothetical learning trajectory is developed based on literature; it is adjusted to students' actual learning during the pilot and teaching experiment.

b. Teaching experiment

In teaching experiment, instructional activities are tried, revised, and designed on a daily basis during the teaching experiment Gravemeijer [9]. The teaching experiment is aimed at collecting data for answering the research questions. In this research, it is conducted through activity in one meeting which the duration is 70 minutes for the lesson. But before that, the teacher and the researcher discuss the upcoming activity. And after each lesson ends, teacher and researcher make a reflection in order to improve the designed activities.

c. Retrospective analysis

In the retrospective analysis, all the data collected during the teaching experiment are analyzed. The hypothetical learning trajectory is used as a guideline in answering the research questions; it is compared with students' actual learning.

b. Data Collection

a. Preparation phases

In the preparation phase, the data collection is aimed to investigate pre-knowledge of students. It will be collected by doing observation class, interview, and pre-test for all students. The information about students' pre-knowledge will be used to fit the initial HLT (hypothetical learning trajectory) considering the aspect of starting point of students. It can be adjusted before the first cycle is started. The classroom situation is also important to be concerned about how the learning process works in the class. It concerns about social norms and socio-mathematical norms. Data is collected during the lesson of the observation class; it can be received from audio or video recording, and field notes of researcher. The researcher writes field notes based on the lists of the observation points.

b. Preliminary teaching experiment (first cycle)

In the preliminary teaching experiment, the instructional activities are given to four students with respect to the differences in level of understanding (1 high level of students, 2 middle levels of students, and 1 low level of students) which are not different too far. Researcher expects that choosing 4 students will represent the ability of the other students. Four students who are selected are not from the observation class for the next following phase. In this phase, they will be taught by the researcher or one of mathematics teacher who will do teaching experiment later on; expecting that the teacher will know better the learning trajectory before the second cycle of teaching experiment is began. During the learning process, it is recorded by one video recording

which is focused on all students; also field notes of researcher. The aim of the preliminary teaching experiment is collecting data to support the adjustment of the initial HLT.

c. Teaching experiment (second cycle)

In the teaching experiment phase, the HLT which has been improved will be tried out. It will be given to all students in one class, but for the analysis of the experiment it will be focused on four students only (one group of four students). Data is gathered through two video recording, one camera, and field notes. One video recording is put in the corner of the classroom in order to record most of the situation of learning process. And another video is placed in front of the group which consists of four students. Also, one camera is used to take some pictures in which there are interesting moments related to the experiment, such as students' strategy when they try to solve the problem, and so on. Here, the researcher has a role as an observer and makes some notes; researcher is only focus to the group of four. Moreover, the teaching experiment of the second cycle has an aim to answer the research question.

d. Post-test

In the post-test phase, the test is used to assess students' understanding after the lesson is finished. It can measure students' ability whether the lesson is succeeded or not. The test is in written form which consists of 10 problems; the problems are in the same form with the pre-test. The post-test will be given both in the first cycle and the second cycle at the end of the activities. Four students who are focused on this study are interviewed to know more about their answer on the post-test problem. It is used to find out what their thinking and reasoning toward the problem. In this phase, data is collected through one video recording (during the post-test and interview session) and field notes of researcher.

e. Validity and reliability

In this study, the different types of data are involved, such as video observations, students' worksheet, field notes, and interview data. The method of triangulation data will be done by involving different types of data. Then, the triangulation data and also testing conjectures of the HLT during the teaching experiment contribute to the internal validity of the data. Data registration will convince ourselves that researcher works in a reliable way because the data was collected by different methods; collecting data by a video recording is more objective than making field notes.

c. Data Analysis

a. Pre-test

In the pre-test phase, the result of data pre-test (students' answer and calculation) is analyzed to investigate starting points of students in learning about decimals. The test result is expected to reveal students' prior knowledge about decimals; it can direct the HLT in such a way in order to make it appropriates for students.

b. Preliminary teaching experiment (first cycle)

In the preliminary teaching experiment phase, the video recording and the students' worksheet are analyzed to find out the useful of the learning process. Officially there is a possibility that the conjectures of our HLT does not appropriate with real situation. Here, the HLT needs improvement because sometimes it fits students in learning process and sometimes it does not appropriate for them.

c. Teaching experiment (second cycle)

In the teaching experiment phase, the video and the students' worksheet are analyzed; these four students will be focused more than the others. Their thinking and also their development from the beginning of the study until the end will be analyzed. However, it is still possible to the other students to be analyzed. If there is a situation or a statement which is supported the learning process, it can be that (s)he will be included to be analyzed in this study.

d. Post-test

In the post-test phase, the result of the test is analyzed to measure students' understanding after the lesson has finished. It also can be compared to the result of the pre-test finding out whether there is any improvement or not. A post-test has an aim to investigate students' development in understanding the concept of place value in learning decimals.

e. Reliability

In this study, the reliability of the data analysis covers two aspects, track-ability and inter-subjectivity. Giving a clear description on how the work on this study so that the reader will easily understand the way of track-ability. The description contains the explanation of the process of how the preparation phase is done, how the teaching experiment phase (first and second cycle) is happened, and how the research analyzes the data; also provide conclusion. In addition, discussing with colleagues can avoid the researcher's own viewpoint toward data analysis; it is needed to attain inter-subjectivity.

3. Result and Analysis

Practically, students could be experienced with the real situation and with facing contextual problems. Some activities were provided in this research as a learning trajectory of activities. Each activity has different aim of learning that supporting the goal of the research. All activities were added by contextual problems. Researchers provide a wide range of contextual issues that students will be expected to finish in a group, as shown in figure 1.

Figure 1. Students work in a group

There are 6 pieces about the difficulties of different problems. One last question is a matter of own production, here the student was expected to make a question about the sum of decimal numbers by themselves. Students from the focus group did not get to work on this number because running out of the time; they were spent too long at the beginning. While the answer from the other groups, many of them made a decimals problem in abstract level, without context and numbers only (shown in figure 2). But some groups created problems using a context that they understand indeed, such as a context of a variety of grocery shopping (in kg) which was shown in Figure 2.

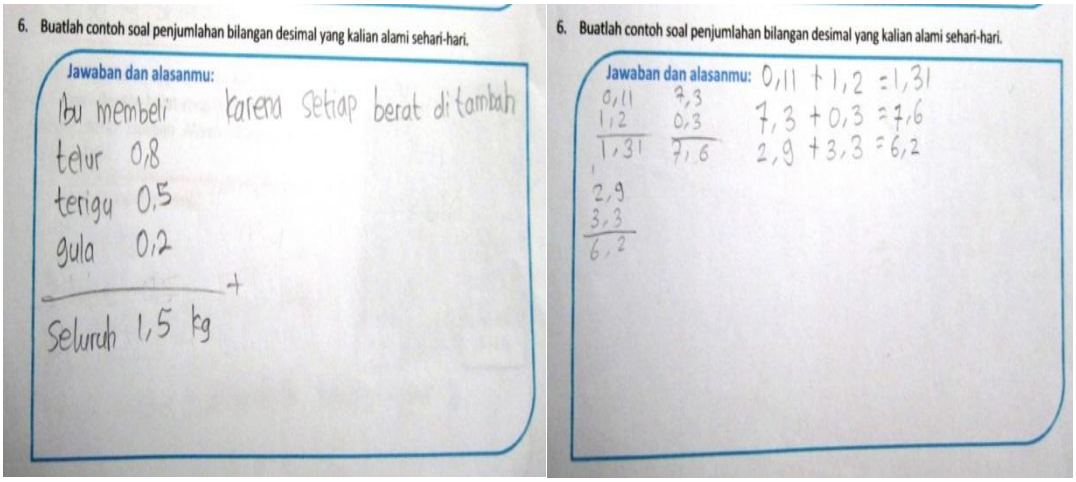

Figure 2. Students' own production

In question 1, there was an interesting discussion between teachers and students. This discussion occurred in another group not a focus group.

Student : "Teacher, teacher... is it 0.10 kg just like 1 kg mam?"
Teacher : "Well.. just write it like that ..."
"And why could it be like that?"
Student : "0.9 plus 0.1 grams is the same as 1 kilogram mam... it means the same with 0.10 mam ... "
Teacher : "What is the value of 1 in 0.1? tenth? 9 at 0.9 "
Student : "Tenth"

Here we can see that the students still assume that 0.10 kg is the same with 1 kg. This issue is problem that is beyond the conjecture of the researcher, and in the 1st cycle, this problem did not arise. Also with this number, this has the same problem of students' solution with number 1 (Figure 3). Therefore, further analysis is needed.

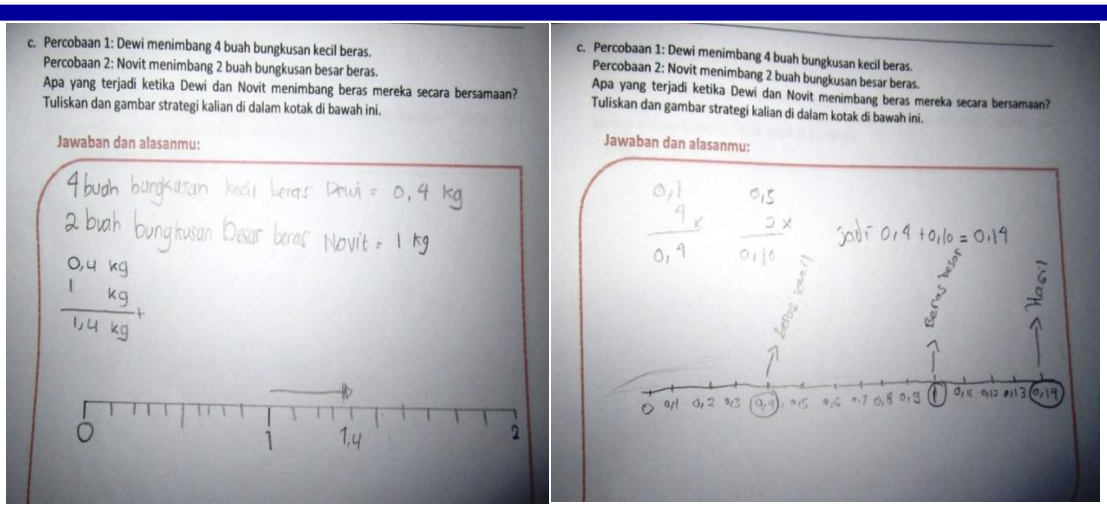

Figure 3. Students' answer number c

For the other problems, for example number 2, it is about adding 19.72 kg to 9 kg. In the focus group, they were confuse, what number should they add up with 9. Researcher tries to facilitate them to remember the place value of each number, so they can easily add up the same value of numbers. While on the other groups, their answers mostly correct, no more mistakes add 9 to 2, but there are still errors of the two groups, they add up 9 to 1, such as: 19.72 + 9 = 109.72 (Figure 4). This means that some children still do not understand the true concept of place value in decimal numbers.

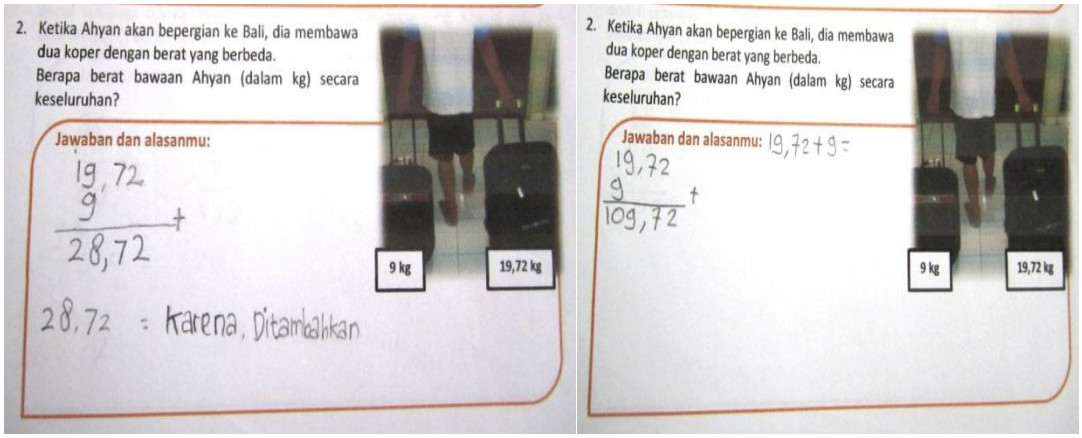

Figure 4. Students' answer number 2

Another number that in line with the error of students' work in number 2 is number b. From this number, we could see that students not only gave their answer but also their strategies in the form of drawing. It was start from the contextual problem, students imagined the situation and then they draw it. From these two pictures (Figure 5), one picture was not exactly right (the left one).

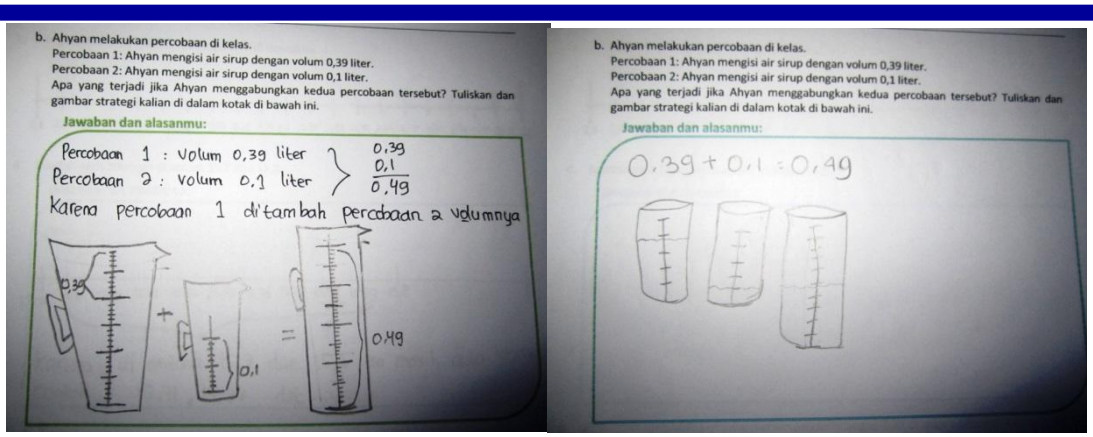

Figure 5. Students' answer number b.

Many hypotheticals of students made by researcher did actually match with the real situation. But, there are some things that beyond researcher doubt. This can be due to many things, such as the design of the activities, teacher's explanation, the way of content delivery, miscommunication between teacher and researcher, and so on.

Meanwhile, seeing the implementation of instructional design of PMRI reflects how characteristics of RME be a grounded theory for the activity where the concept of place value in decimals. It is inspired by Bakker [11]. The first characteristic of RME is phenomenological exploration, better understanding of the basic conceptual mathematics in decimal numbers, rich context and meaningful problems and also necessary activities. Using context which is familiar with students, this activity motivated students in learning and made a meaningful teaching and learning process.

The second characteristic of RME is using models and symbols for progressive mathematization, bridging 'the gap' between the concrete and the abstract level, the models and symbols used. Diversity of models and symbols, and also the design of activity intended to bring students to develop their knowledge.

The third characteristic is using students' own construction and productions. Students are free to use their own strategies; it became the foundation for them as a solution that could be used in the further studies. Through the activity and also class discussions, students could build their own understanding of decimals with minimal guidance. They made some groups depending on the place value in decimals, separating the tenth, hundredth, and thousandth.

The fourth characteristic is interactivity. Student learning is not only an individual learning process but also a process of social learning. From the models made by them (e.g. drawing a representation of carton) the interaction among students is occurred; it made the discussion became more meaningful, such as learning from the others. Role of the teacher is only as a facilitator that connects student with others so that the students could find by themselves the understanding of the place value concept in decimal numbers.

The fifth characteristic, intertwinement, integration of learning topics could help students learn math in an effective way, and learn place value concept of decimal

number could be combined with other topics such as fractions, percent, ratio, and measurement.

4. Conclusion and Suggestion

The goal of this research is to scaffold students' thinking and to help them be motivated in teaching learning process. The idea was an understanding of decimal numbers problem using contextual situations. There is one research question needed to be answered. The research question is: *"How can contextual problems support students' thinking to understand decimals?"* From the results and analysis, it has been clear that the application of contextual problem is success overall. In the beginning of the study, contextual problem is rather difficult for students so that its need time to be understood. From the process, students learn decimals more meaningful through contextual situation; until the learning process is done. Moreover, this research can be developed more in the other topics. Not only restricted in decimal numbers but also other topics especially the topic which needs an implantation of concept. As a final conclusion, this research result can be used as guidance for teacher who wants to apply the activity and also can be used for the other researcher as a reference for further studies.

Acknowledgements This work was carried out with some people involvement. As a researcher, I thank to the teachers and students who participated. Thanks are also due to my friends for assistance and comments. Thanks to my big family for the support.

References

[1] Steinle, V. & Stacey, K. The Incidence of Misconceptions of Decimal Notation Amongst Students in Grade 5 To 10. In C. Kanes, M. Goos & E. Warren (Eds), Proceedings of the 21st annual conference of the Mathematics Education Research Group of Australia (Vol. 2, pp. 548-555). Gold Coast, Australia: MERGA, 1998a.

[2] Ubuz, B. & Yayan, B. Primary teachers' subject matter knowledge: Decimals. International Journal of Mathematical Education in Science and Technology, 41(6), 787-804, 2010.

[3] Irwin, K. C. & Britt, M. S. Operating with Decimal Fractions as a Part-Whole Concept. New Zealand Numeracy Project, New Zealand Ministry of Education, 2004.

[4] Widjaja, W. Local Instruction Theory on Decimals: The Case of Indonesian Pre-Service Teachers. Australia: University of Melbourne, 2008.

[5] Irwin, K. C. Difficulties with decimals and using everyday contexts to overcome them. Journal for Research in Mathematics Education, 32, 399-421, 2001.

[6] Zulkardi. Developing A Learning Environment on Realistic Mathematics Education For Indonesian Student Teachers. Enschede: Twente University, 2002.

[7] Pramudiani, P. Students' learning of comparing the magnitude of one-digit and two-digit decimals using number line. A Design Research on Decimals at Grade 5 in Indonesian Primary School. Sriwijaya University-Utrecht University, 2011.
[8] Gravemeijer, K. & Cobb, P. Design research from the learning design perspective. Educational design research (pp. 17-51), London: Routladge, 2006.
[9] Gravemeijer. Developing Realistic Mathematics Education. Utrecht: Freudenthal Institute, 1994.
[10] Barnett, C., Goldenstein, D., & Jackson, B. (Eds.). Fractions, decimals, ratios, and percents: Hard to teach and hard to learn? (Mathematics teaching cases), Portsmouth, NH: Heinemann, 1994.
[11] Bakker, A. Design Research in Statistics Education. On Symbolizing and Computer Tools, Amersfoort: Wilco Press, 2004.